§1. Injection Performance of Neutral Beam Injection System in the 13th Campaign

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The LHD is equipped with three negative-ion-based neutral beam injectors of BL1, BL2 and BL3, and one positive-ion-based neutral beam injector of BL4. In the LHD, the neutral beam injection (NBI) system should be reliably operated as a main heating system, to extend the plasma operation regime in the mission-oriented experiments and to explore the plasma properties in the physics-theme experiments. In the negative-NBI high-energy hydrogen beams are tangentially injected at 180keV while low-energy beams are perpendicularly injected at 40keV in the positive-NBI. Operational performance of both NBI systems is summarized in the 13th LHD experimental campaign.

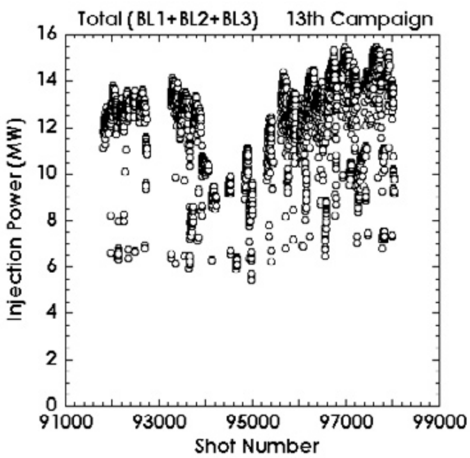

Fig. 1. Shot evolution of the total injection power for the negative-NB injectors in the 13th campaign.

The total injection power with three negative-NB injectors are summarized in Fig. 1. The maximum injection power is 15.5MW exceeding the designed value of 15MW. Three arc chambers in BL2 and BL3 were locally melted by the abnormal arcing, and the available ion sources are restricted for the repair in a period of 94,000 to 95,500 of the shot number. After the recovery, the injection power was gradually increased and reached 15.5MW.

Figure 2 shows the shot evolutions of the injection power for individual negative-NB injectors. In BL1, the negative ion sources employ the multi-slotted grounded grid (GG) for the accelerator. By optimizing the cesium supply, stable high-power injection of around 6MW is successfully carried out. The maximum injection power is 7MW for 1.6s with the energy of 190keV.

In BL2 and BL3, three out of four arc chambers were successively damaged by occasional abnormal arcing between the filament holder of the feedthrough and the chamber wall, which leads to air leaks. In a period of the repair, the operation was suspended or restricted with one ion source. To avoid the local abnormal arcing, a shape of the filament holder will be modified for the next campaign. After the recovery of the arc chambers, the ion sources were prudently operated, and, thus, the achieved injection powers are restricted to 4.6MW and 4.8MW in BL2 and BL3, respectively.

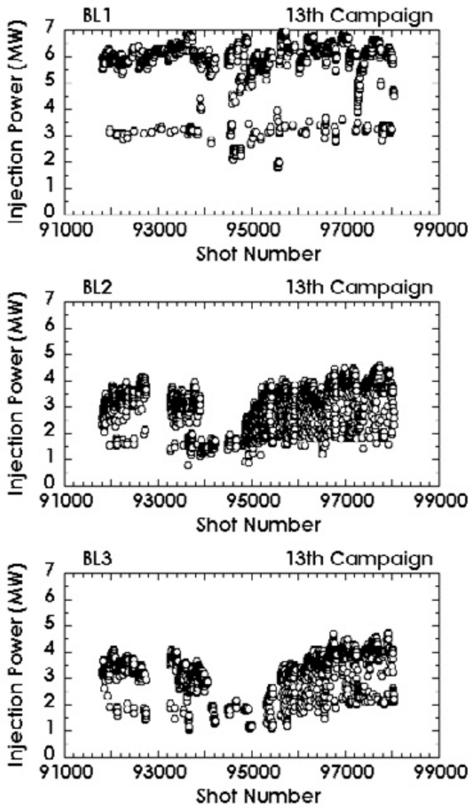

Fig. 2. Shot evolutions of the injection power for individual negative-NB injectors of BL1, BL2, and BL3.

The operation of the positive-NBI of BL4 was extremely stable without any troubles. The injection power is as high as 6MW for the high-T_i experiments although the pulse duration is limited below 0.5s to avoid an excess heat load on the residual beamdump. The pulse-modulated injection was also reliable for the T_i-profile measurement with the CXS method.

Now, the total injection power with the negative- and the positive-NBIs are more than 21MW, which greatly contributes to the LHD experiments.

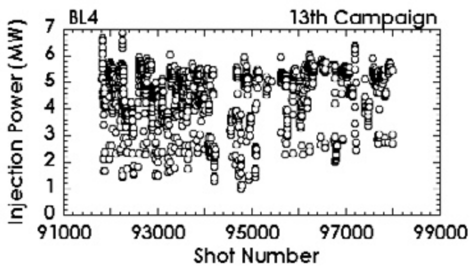

Fig. 3. Shot evolution of the injection power for the positive-NB injector of BL4 in the 13th campaign.